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ABSTRACT

Possible futures for the world of mainframe computers can be forecast through studies identifying forces of change and their impact on current trends. Some new prospects for the future have been generated by advances in information technology; for example, recent United States successes in applied artificial intelligence (AI) have created new opportunities for the computer and communication industries. The Japanese reacted to the breakthrough of practical artificial intelligence with their own projects. The United States and Europe quickly reacted to the Japanese with such research and development projects as the Semiconduction Research Corporation, the Department of Defense Advanced Research Projects Administration, and the European Strategic Program for Research and Information Technology. New developments spawned by international competitive forces for change have resulted in forecastable expectations for more capabilities and lower costs in chip and wafer-scale component integration, micro-sensors, communication links and interfaces, AI expert knowledge bases, and micro-controllers and activators. With such technological advances, new computerized communications systems will become possible, such as current awareness systems and cooperative systems, and the new computer revolution that is beginning now will have a strong impact on society in the late 1980's and 1990's. (LMM)

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(SOME) COMPUTER FUTURES: MAINFRAMES

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INTRODUCTION

This paper is about possible futures for the world of mainframe computers. As computer, communications, and telecommunications are increasingly married, advanced developments in one, in turn, radically impacts the others.

During the remainder of the 1980s, advances in computers are expected to jump from their past-driven trend track, leaping to a faster future trend track. New developments spawned by international competitive forces for change can now be forecasted to spin new trends accelerating one to two orders of magnitude faster than past trends.

As a result, a new computer revolution must be forecasted, now birthing, for impacting society in the late 1980's and the 1990 decade.

FORECASTING

This paper's sequence will discuss future computer possibilities in roughly the sequence that a futurist uses in investigating and forecasting possible futures: trends, forces of change and the analysis of R&D, goals, strategies, plans, and their assessments.

To forecast the future of anything, the process usually begins with a study of past and present rates of change, and their extrapolation. If analysis of possible futures ended here, we would mirror only past change upon the future. Thus, extrapolation of past change results in the forecast of one set of possible futures--not necessarily the future we will actually experience.

After trend extrapolation, we investigate current and possible future "forces of change" operating on the trends to "steer" them into a multiplicity of different directions into the future. The result is another set of possible futures--again, not necessarily predictions of what "will" happen, but forecasts of what "could" happen. Forces of change come in many forms and types--advances in technology, political actions, competitive practices, international/global interactions, social reactions, and the like; these can leverage and steer the developing future in different directions.

Next, in our investigation of possible futures we apply other "forecasting tools" for identifying and understanding those processes currently underway which create, design, control, and manage various aspects of the future; e.g., plans, strategies, research and development efforts, decisions, inventions, and so forth--efforts that are allocating resources to create parts of the future. Once these are discovered, they are analyzed for their potential capabilities for synthesizing new futures and forecasts; as either new future trends, forces of change, or as breakthroughs which will initiate new possibilities. From such a scientific/systematic analysis and/or snythesis of the future, another set of

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possible futures is identified. Like the other sets, this will not necessarily be the actual set of futures to unfold.

Throughout such analysis and assessment of possible futures, better estimates/forecasts are made to determine which futures are most likely.

Through such studies, investigating identifiable and forecastable forces of change and their impact on current trends, futurists apply an analytical/scientific process for generating forecasts of possible futures. Further, in applying such a model to the study of the future, we end up with a "science" for dealing with the future, e.g., the anticipatory sciences.

Even with all this "science" for forecasting and for increasing our understanding of alternative futures, except in a very few cases, we cannot predict the future.

Why? The answer is simply that we don't know our world and our systems well enough, nor can we identify all the trends, forces of change, breakthroughs, plans, etc. Since our knowledge is only partial relative to the "components of change" and to our systems, we can only forecast the "could be's" rather than the "will be's." However, the more science and effort we put into forecasting, the more we improve our knowledge of what is possible for the future.

Therefore, with the anticipatory sciences, our forecasting gives us the ability to telescope in on possible futures well enough so that we are willing to bet our lives, careers, institutions' resources, to bring about particular futures or to avoid others.

Futurists, with their forecasts and by the very nature of their tasks, are at the leading edge and usually on the other side of prevailing thinking and tendencies. The further out forecasts are, the less detail is possible. Futurists can't explain everything about the advances forecasted nor all of their ramifications. If they could, such forecasts would not be about the leading edge of advance and change; rather they would be forecasts about the present, imaged upon the future, with slight evolutionary future perturbations of the past.

A FEW COMPUTER TRENDS

Mapped over past decades, the rate of change advances in cost-performance ratios in mainframe computers has been on a trend track with a factor of ten times improvement per decade--or a 30 percent per year gain has been the average experience. The number of transactions per second at the interface of computers over communication links has a track record with only a multiplicative factor of five times improvement per decade. Most computer logic circuit hardware areas have been improving by 30 percent per year, memory at 40 percent per year, and communications hardware at 10 percent per year.

There is no real scientific and technological basis/evidence for forecasting that these trends could not continue into the long-range future. Through an investigation of non-technological forces--market, competitive, international, business--some evidence can be found for forecasting both a speeding up or slowing down of these past rate-of-change trends. However, detailed investigation of the forces of change vividly indicate a speed up. To

understand why, this paper maps out many reasons; one is the Japanese thrust and a world reactive force for change. Prior to 1981, visions of recession and other market forces pointed toward a slowdown in the introduction of new technology, but now the picture for the 1980's and 1990's has been radically altered.

In 1981 Japan again announced war--an economic/computer war--and shocked the computer and telecommunications worlds. They announced a Fifth Generation of computers for the 1990's.

Another initiated trend and force of change was altered when the U.S. Justice Department answered the question of whether or not future communications systems will come in any brand name other than AT&T. With the split-up of AT&T, competition is the name of the game. As a result, communications manufacturers, including AT&T, are also becoming computer companies, and mainframe computer manufacturers, including IBM, are marching faster toward becoming a part of the communications industry. The communications manufacturers are also getting into another new business, the delivery of information--initiating information utilities.

In such a future information environment, now birthing, trends point to a long list of new information-related, new computer applications--many of which have their precursors in the primitive data base management systems, management information systems, decision support systems, and computer-aided-design/instruction systems now in place. For the computer world, this neo-modern information age into which we are leaping, evolutionary advance is the name of the game, rather than revolution--even though to society it seems revolutionary relative to the magnitude of change occurring and to the impacts expected and forecastable.

For example, the current computer revolution differs in several critical aspects from the early 1950s when computers and automation were introduced. First, computer applications are changing (1) from large, centralized, and costly computer hardware and software to distributed, personal, and low-cost systems; (2) from use of computers by a few large firms (e.g., the military, big businesses, and the Federal Government) to use by individuals at work, students in school, and family members at home and embeddment into a wide variety of machines; (3) from displacing and deskilling "low-level" jobs to displacing and deskilling "high-level" jobs; (4) from creating more jobs than are displaced to the real possibility of displacing jobs faster than society can create new ones; (5) from automating industrial-age jobs to automating information-age systems and jobs; and (6) from computer systems that require considerable education and software development in order to apply them to easy-to-use systems with a vast array of ready-to-use, packaged software.

But the most major change is that total computer system and usage costs are decreasing ever faster while, at the same time, their functionality and applicability are increasing. Thus, computers have passed the threshold of affordability and are entering an era of being involved in our daily lives and are being massively employed and embedded into communications systems.

Taken as a whole, these trends allow for both the short- and long-term future reality of growing beyond science fiction--allowing for a "Star Trek"-like future as we take the next steps toward artificially intelligent "inference

engine"-type computerized communication systems.

Rapid technology change always has been the norm in the computer field and, recently, in the communication field. As in the past, technology-driven change is forcing an increasing diversity and growing new alternatives.

But, whichever directions the information age takes into the future, technological developments will allow computer and communication systems to penetrate deeper into society, providing new opportunities for individuals, institutions, and society--and most importantly--for management and the businesses/institutions that they are leading into the information-age future.

THE JAPANESE THRUST

In the late 1970s, the Japanese were studying their future relative to high technology. They discovered from their forecasts that in the 1990s they would be deep within the information revolution age--with perhaps as much has 90 percent of their population earning their livelihood from information age jobs. Their analysis indicated to them that in order to have a high quality of life in such an age, their nation would need to become a major producer of information technology world-wide. As a result, in 1979 they established Project ICOT--the Fifth Generation computer project for implementing artificial intelligence (AI). In 1981 they shocked the world with their announcement of this project. The Japanese then stated that they had only 15 percent of the world's market in information (computer and communications) technology but that they were taking steps to initiate the building of an industrial base and the designing of future hardware, software, computer, and communications technology to penetrate the world information technology market to the level of 40 percent by 1990!

The U.S. currently had the lion's share of the world's information technology. Therefore, this announcement was tantamount to a declaration of an economic war with the U.S.--and more specificially with IBM--because the gain in the Japanese market share would have to come out of projected U.S. and IBM markets.

The Japanese then invited computer scientists, knowledge scientists, and knowledge engineers from IBM, the U.S., Canada, and Europe to a conference in Japan. At the conference the Japanese promised to describe in detail (and they did) the science, technology and businesses they were creating for their Fifth Generation computer and information technology project. In return, they invited our scientists to be on the agenda to present their/our latest scientific knowledge in areas of interest to the Japanese. We rushed over to Japan to help them put us out of our future business! The result: we learned, and they learned.

The magnitude of this Japanese Project ICOT (as reported) is:

* $1.3 billion to be spent over a ten-year period;
* Eight Japanese firms are cooperating;
* The architecture for a knowledge inference processing system (KIPS) has been initially designed, and work progresses towards its implementation--an artificial intelligent computer system far exceeding the capability (by 1,000 times or more) of any planned elsewhere.

A less well-known Japanese project involves six firms. Its specific goal is to achieve a high-speed computer 1,000 times faster than our CRAY Computer. Additionally, this project proposes to significantly advance the state-of-the-art in picture/image processing and to greatly improve information technology. Its projected funding for a ten-year period is $100 million.

These two projects are pegged to create in the next decade, the 1990s, a new computer generation whose characteristics will include major advances in the hardware and software for artificial intelligence and expert knowledge base systems. The computer field is investing in this belief with considerable R&D world-wide. The emphasis is on applied AI, non-numeric data processing, symbol manipulation, image processing, and on new computer architectures, hardware, and software to support these efforts. In the realm of conventional computers, the Japanese plan to increase by as much as three orders of magnitude (1,000 times) the performance capabilities of super computer mainframes and data base computer networks. In the AI arena, the Japanese are designing new parallel inference systems; AI languages; personal sequential inference computers; problem-solving machines; relational data based systems; basic hardware mechanisms for association, learning, inference, knowledge bases, user-oriented human-machine interfaces, and software environments.

These two projects, to restate, have as their specific goals to leap-frog U.S. information technology by three orders of magnitude.

U.S. REACTION

This great thrust by the Japanese to create an advanced information era has caused considerable reaction in the U.S. and Europe.

Ironically, MITI (the Japanese Ministry of International Trade and Industry) sold its Japanese industrial partners (who are funding about half of the bill) on the Fifth Generation Computer System (FGCS) Project as a way of catching up with the Americans--and to leap-frog over us in some areas. MITI was successful with this marketing approach.

In America, this Japanese push came as a threat to our computer, communications, and AI fields and industries--as we envisioned in the high tech areas--a repeat of Japanese economic and industrial triumps in watches, autos, cameras, steel, consumer electronics, and TV. As a result, the U.S. Department of Defense (DOD), academic AI researchers, and the U.S. computer industry are reacting strongly. Their strategy is to sell their projects to the powers holding the purse strings for the purpose of catching up, staying ahead, and leap-frogging the Japanese, depending upon the case being made. Their weapon for achieving high funding levels is the scenario of a decisive competitive advantage by the Japanese should they be successful in achieving a fraction of their current goals.

The response in the U.S. as well as in Britain and Europe has been swift. Top priority projects are now being planned, programmed and/or implemented for developing the next generation of information technology with step-function increased capability in computer, communication, and AI systems.

In the U.S. there are at least five major areas of reactive activity that point toward retaining our lead and for leap-frogging the Japanese thrust.

First, fourteen U.S. companies are taking advantage of the government's relaxed attitude toward anti-trust. They have formed a research consortium--the Microelectronics and Computer Corporation (MCC) based in Austin, Texas. The purpose of the corporation is long-term, "precompetitive" research. Precompetitive research so far is not defined, but it is basically that research which the companies are willing to collaborate on. As of yet, IBM is not one of the partners; therefore, it probably is safe to assume that MCC has an additional goal to compete with IBM, too.

There are only two ways to keep abreast of a competitor's heading into the future--either hire a futurist to complete a forecast or hire a spy. MCC essentially chose the later route by hiring Admiral Bobby Inman, former deputy director of the CIA, as its president. MCC plans to spend about $1.3 billion in ten years--$600 million in its first five years to achieve its goals in AI, advanced microelectronics, and advanced computer architectures. Included are projects to advance image processing, CAD/CAM, software, software engineering, component packaging and protean (bio-genetic electronic) hardware and computers.

Why is the U.S. allowing this type of research cooperation among computer companies when there are monopoly laws that forbid such actions? One answer is that the U.S. has been caught short in developing a resource of qualified research scientists and engineers in this rapidly developing area of computers and AI. Another is the cost involved. The cost to create a new computer generation now far exceeds $10 billion. Imagine each computer and communications company having to find billions of dollars to do their own R&D. Obviously, in either scenario there would not be a sufficient number of professionals or enough venture capital to do the job. Consequently, for the U.S. to stay ahead, the decision is to allow cooperation within the industry. Entrepreneurs are now finding that this new thrust has created the incentive for many venture capital dollars to surface.

Another U.S. cooperative project involving about 23 firms is SRC (Semiconduction Research Corporation). Their goal is to regain the lead in information technology hardware since the Japanese have in recent years come to the world marketplace with the latest state-of-the-art hardware, a few months ahead of ours. This cooperative effort will fund universities to do basic hardware research. At first glance, such an effort seems to be misapplied because nearly everyone knows that the rapid advances in computers and communications have come from advances in hardware over the last three decades. The problem is that we became over-confident and so reduced our efforts in basic hardware research and turned more of our R&D dollars to development, allowing the Japanese to leap-frog our technology. Thus they are reaping marketplace and economic benefits of continued hardware research.

A third area of increased funding and R&D effort, resulting from our reaction to the Japanese jump into AI, is the step-up of R&D by the U.S. computer manufacturers. Just prior to the new Japanese effort, U.S. computer manufacturers were spending about $3 billion a year on R&D--most of it, of course, was on the D side of R&D. IBM, with the lion's share of the world information technology market (over 60 percent), was spending about 40 percent of total U.S. manufacturers' R&D budget. This was considerably less than its market share percentage, making IBM possibly vulnerable for the future. With

the Japanese announcement, IBM reacted by increasing its R&D budget by about a third; other U.S. computer manufacturers followed suit and also increased their R&D. This year the U.S. computer manufacturers should spend $5 to $6 billion on R&D; however, this range is fuzzy because of the differing definitions of what constitutes R&D. Nevertheless, the trend is upward with more allocated for basic research--and it should continue to rise up in the years ahead.

A fourth area of expanded R&D in the U.S. is the DOD Advanced Research Projects Administration (DARPA). The Japanese hoopla provided leverage for DARPA, the research agency of the Pentagon, to obtain its ten-year, ambitious strategic computing program--expected funding at the $1 billion plus level. Its initial five-year $600 million program is for developing AI and information/computer technology. Its long-term military electronics goals include projects to create a totally new generation of computers with capabilities for AI, vision, reasoning, speech comprehension, and a diverse set of military applications and an elaborate computer system (with an AI expert knowledge base) for assisting strategic planning efforts. Additionally, and in some cases with other funds, DARPA has a Fifth Generation AI computer project, the ADA Project, CAD/CAM integration and advance project, the VHSIC (Very High Speed Integrated Circuit) Project, and a factory automation project. The latter is to upgrade those U.S. factories involved in defense work to factory-of-the-future status in order to leap-frog the Japanese in this important area for our future.

The NSF (National Science Foundation) is also funding a number of information technology, computer, and communication research projects. However, their funding level is considerably lower than the others. Of note is their funding of basic research in the bio-chip area which has seen some breakthroughs, promising future new bio-electronic computer and communications technology.

Trilogy, a small new company headed by Amdahl, has recently hit the scene. Sperry, CDC, Honeywell, and DEC have invested in Trilogy and are making a cooperative effort to advance into wafer-scale integration for their future information technology components. IBM is also investing R&D in wafer-scale integration.

In recent decades, especially the late 1970s, the U.S. spent its R&D efforts (public, private, and defense) primarily in applications-oriented and product development areas and very little in basic research. It appears that the Japanese recognized this error in our ways and leaped into the gap with basic research--from which they are now reaping some benefits in the marketplace. Hopefully, we will learn from this state of affairs; but we have been slow to increase our basic research efforts.

EUROPEAN REACTION

Now, let's turn to Europe to investigate the magnitude of their reaction to the Japanese. In the 1970s, Europe allowed the silicon age in the U.S. and Japan to leave them in the dust of adverse technological and economic impacts. In an attempt to stem the tide of AI, Europe has embarked upon a number of ambitious new programs. Further, their studies indicate the folly of ignoring the information age which is thundering in world-wide and changing society in its aftershock.

By far, their largest planned effort is the EEC's European Strategic Program

for Research and Information Technology (ESPRIT) Program. It is envisioned as a five-year, $1.3 billion venture in advancing information technology--if they can get the EEC Commission to quit wrangling and to agree to funding it jointly with private industry. ESPRIT, as currently planned, has selected five project areas: (1) process control and computer-integrated manufacturing; (2) advanced VLSI and VHSIC microelectronics; (3) software technology; (4) office automation; (5) advanced information processing, including AI. So far, twelve firms have signed up to cooperate in ESPRIT.

In the U.K., Britain has launched its version of research for the Fifth Generation computer--the Alvey Programme--to the tune of $1/2 billion to be spent in five years. The Alvey Programme is interesting from a number of standpoints. It has about six "cells" (projects) for advancing information technology: (1) VLSI; (2) software engineering; (3) an AI Intelligent Knowledge-Based System (IKBS); (4) human-machine interface; (5) networks; (6) CAD. Its funding is coming from: (1) a number of government agencies; (2) private industry (a number of companies); and (3) users! Because users are involved, this should be a major project to watch; it should come up with some good ways to make information technology more useful and with better human-machine interfaces, rather than just elegant hardware or software.

Europe also has a MCC project involving three countries and three companies. ICL in the U.K., Siemans in West Germany, and Bull in France have agreed to cooperate for long-range research into AI and expert systems. Funding is at less than $10 million per year--about the same level of funding as the Japan Institute for New Generation Computer Technology (which they are apparently copying).

One reason we should watch these European, and especially the U.K., efforts is because of their belief that they are the innovators of the world--far better than the U.S. and Japan. They may be right--at least in some areas--as we can see when we look for the source of some of the great computer breakthroughs in the past. Further, there is a bigger "brain drain" (from Europe to the U.S.) now than there was when it was a newspaper headline topic a few years ago. They realize this and therefore are expecting these projects to stall or even reverse the brain drain--which could be scary for the U.S.

RESULTING NEW TRENDS, ASSESSMENTS, AND CONSEQUENCES

There are other computer R&D projects, but these appear at the moment to be the big ones that will change the face of mainframe computers - and information technology, the total computer industry, and society. All in all, these efforts will, if sustained, add in this decade over $30 billion additional R&D dollars! This is in addition to past trend figures to advance and reshape information technology: computers, communications, AI and society. Such a huge infusion of new effort over the relatively short period of ten years cannot help but radically alter the shape of the information technology industry and the world's infrastructure. It will revolutionalize society as it speeds automation, computerization, and communications.

This new computer technological revolution will change our way of life--how we work; what we work at; our offices, factories, and schools; how we initially interface with people and policy making (instead of in smoke-filled rooms, we will communicate remotely via new information technology), and much more.

The magnitude of these new R&D efforts in Japan, the U.S., and Europe are causing, and will continue to cause, trends to jump to the fast track for the future.

But by how much?

As stated earlier, the average cost-performance trends for mainframe computers has been improving by about a factor of ten per decade. Microcomputers have been improving a little faster--about a factor of 20 per decade. For the future, the late 1980s or early 1990s, the cited R&D and competitive forces of change (new goals, new strategies, and new plans) can be forecasted to speed the trends towards:

* Super computers and mainframes which are 1,000 times faster;
* Memory and circuits with 100 times more performance capability and even more cost effectiveness;
* Microcomputers, PCs, and chip/wafer computers with 1,000 (plus) times more capacity per unit and with a performance capability approaching today's super computers;
* Transactions per second at the interface which are 1,000 (plus) times more cost effective;
* New capabilities (with improvements of large orders of magnitude) of:
  - parallel architectures
  - AI architectures and systems
  - data base and knowledge base systems
  - image and picture processing
  - office and factory automation
  - CAD/CAM
  - DSS/MIS
  - process control
  - robotics
  - VHSIC and VLSI
  - software and software engineering
  - explosive growth in application programs
  - bio-chips and DNA computers.

Because of the closer marriage of computers and communications, most of the advances cited so far will also impact the communications world. Much of the forecasted R&D effort will be directed at communications hardware and systems to provide new breakthroughs, rapid evolutionary advances, and new capabilities. Because of the forecast for considerably faster and higher capacity, memory and computers, communication speeds and bandwidths will need to be also advanced. Further, new or greatly improved approaches--architectures, hardware, and software--for networks, interfacing, transmission paths, store and forwarding switching (including message switching), displays/graphics, telecommunications, terminals, videotex, fiber optics, satellite communications, lazer disc systems, communicaters (hand-held), and voice systems (and speech recognition) are forecastable.

With more remoted/networked systems which have considerably lower cost and with higher capacity memory, more convivial terminals and micro data base computers are forecastable; the true paperless office must become the norm in the 1990s. Since it will be considerably more cost-effective to move, display, and store

information electronically rather than through the use of paper, it will become the gravity flow direction as the path for society to fall into in the future.

CONCLUSION

These and many other prospects for the future are spawned by the new opportunities generated from advances in information technology. Recent successes in the U.S. in applied AI, expert knowledge base programmed systems, created opportunities for a new future path for the computer and communication industries. The Japanese reacted to the breakthrough of practical AI and initiated projects to fill-in some of the gaps existing in the U.S. in this success area. The U.S. and Europe quickly reacted to the Japanese, creating new needs, musts, desires, and opportunities--challenges to solve for the future. The result is forecastable expectations for putting a few kinks in our trend paths from the past toward a future acceleration in technological developments. Thus, at the edge of the long-range future for the 1990's, the wind of technological advances will have been greatly accelerated, resulting in forecasts for impacting society with new computer systems.

SOME POSSIBLE NEW COMPUTER SYSTEMS DIRECTIONS

I will conclude this paper by outlining some new directions.

As technology advances by the forecasted and expected one to three orders of magnitude, with more capabilities and lower costs in: (1) chip and wafer-scale component integration; (2) micro-sensors (speech, voice, image, infra-red, etc.); (3) communication links/highways and interfaces; (4) AI expert knowledge-bases; and (5) micro-controllers and actuators, computerized communications systems become possible. Two examples are:

1. Current Awareness Systems. Mainframe computer systems which can sense their environment, determine what to do relative to the situation at hand, and then initiate action. Systems with their purpose/role embedded as a part of their "intelligence." Systems which are "knowledgeable." Hardware systems which can communicate and discourse with other hardware systems to cooperate on a set of role tasks. All without human intervention.

   Current awareness systems will be increasingly added to robots and other types of automated machines. They will be used as amplifiers to increase and extend the capabilities of humans--as "people amplifiers" for increasing and extending our intelligence and sensory range.

   These current awareness systems, when interfaced through communication links, can be forecasted to allow future humans and machines to be vastly extended and amplified beyond today's more primitive machines. For example, imagine how much an individual would be capable of doing once he or she has access to the total stored knowledge amassed by society (up to about that moment of use)--and is able through the use of AI computers linked via communications in the form of a knowledge based information utility to apply amplified expertise in the real-time of an individual's decisions and actions. Imagine how much office, factory, school, home, and hospital automation could be advanced for creating next generation offices-of-the-future and the like. Imagine further: machines which have

access to more knowledge than a human being possesses--machines which are smarter and more intelligent than humans and, with their embedded initiative, can't wait to tell you about it! Obviously, designers will need to be careful in designing the use of these purposive, current awareness-systems, elsewise they could become insufferable, smart-alecky, nagging bores.

2. Cooperative Systems. Systems capable of cooperating (working together) with other machines on complex tasks, requiring intelligence here to for supplied only by humans--even AI computerized and communicating machines which plan and intelligently alter their tasks, jobs, and roles. Discoursing machines/systems with which humans could have an interesting conversation.

Obviously, just these two example systems will radically alter and change the infrastructure of future society, offices, factories, homes, schools, and much more. They will usher in a new (next age) generation of automation and new mainframe computers futures.

The anticipation for the massive forces of change and amplification of mainframe computers outlined in this paper factors-out for the next decade (and sooner) to be a new computer revolution, much bigger and impactive than the past computer revolutions! Are you still in the B.C. (before using computers) age?